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REINFORCED, MULTI-LAYER COMPONENTS OF THERMOPLASTICS  
[VERSTÄRKTE, MEHRSCICHTIGE BAUTEILE AUS THERMOPLASTEN]

Franz Hackl, et al.

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INVENTOR	(72):	FRANZ HACKL, HEINZ RUHLAND, LUDWIG MAYER, WOLFGANG PENZ, WOLFGANG STOCKREITER and WOLFRAM STADLBAUER
APPLICANT	(71):	PCD-POLYMERE GESELLSCHAFT M.B.H. and LENSER KUNSTSTOFF-PRESSWERK GMBH & CO. KG
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## Description

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Components with layer structure have been known for a fairly long time and are used in many areas. For example, in highly-specialized plywood panels for modern skiers, a highly-reinforced base and cover layer are held at a defined, variable distance by a core with variable thickness and many types of composition. The flexural strength of the skis is adjusted exactly according to the requirements by the properties of the layers, especially their thickness. Previously high flexural strength was achieved by cover layers with many reinforcement fibers per surface unit and by a large spacing of them, i.e., by a thick core. Both mean high weight and in any case, high costs per surface unit. Another option for achieving high flexural strength involves so-called honeycomb panels.

From DE-OS 42 08 812, a multilayer lightweight panel is known that is constructed of a support core with honeycomb structure lying on the inside and two cover layers of thermoplastic films lying on the outside. Current lightweight panels are preferably used as structural components, say in motor vehicle or aircraft construction or in the building industry and are distinguished mainly by their high strength and stiffness with simultaneous low density. The disadvantage of the panels lies especially in the complicated manufacturing of the honeycomb structured support core and the high costs caused by this. High flexural strength in combination with elasticity is of critical importance during use in floor construction, especially with double

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\*Numbers in the margin indicate pagination in the foreign text.

floors to hold cables or in sports floor construction.

Because of this, the need arose to find components that have a simple support core and simultaneously a satisfactory characteristics profile with the properties of flexural strength, combined with reliable deformation.

The object was achieved by a construction in which the core layers contain reinforcement material in unstructured, essentially disconnected form, whereby in the case of fibers these have no preferred orientation and in contrast to that, the cover layers are reinforced with fibers in the form of a coherent surface structure in which the fibers are essentially oriented parallel to the surface.

According to this, the object of the invention is reinforced multilayer components of thermoplastics with at least one core layer that is connected to at least one upper and one lower cover layer that are characterized in that the core layer contains reinforcement material in unstructured and essentially disconnected form and the cover layers have reinforcement fibers in the form of a coherent surface structure, whereby one or more surface layers free of reinforcement layers may be applied.

In this case, all the usual deformable thermoplastics can be used as matrix material for the multilayer components of thermoplastics. Example of these types of thermoplastics include, e.g., polyolefins, polyamides, polyester, polystyrene, styrene copolymers, polyvinyl chloride, polyether sulfones, polyethylene or butylene terephthalate, thermoplastic polyurethanes, polyimides, polysulfone, polyether

ketones, polyether imides, polyphenylene sulfide, but also high-strength and/or high temperature resistant thermoplastics like polycarbonates, polyoxymethylene and the like. Preferably polyolefins, polyamides, polyether sulfones, polyethylene or butylene terephthalate, polystyrene, polyvinyl chloride, polycarbonate, polyether ketones or polyoxymethylene are used. Polyolefins, like polyethylene, polypropylene or ethylene-propylene copolymers are especially preferably used.

The matrix material for the core layer and for the cover layers can be either different or the same, preferably the same matrix materials are used.

A core layer of the components according to the invention contains reinforcement material in unstructured and in essentially disconnected form. These are either fibers or non-fibrous materials. Fibers are understood to mean fibers of glass, carbon, aramide, ceramic or metals, both natural fibers and synthetic and/or semi-synthetic fibers, which are not damaged or not significantly damaged at the processing temperatures of the matrix polymers, e.g., cellulose fibers or hemp. The fibers can be individual or bundled. Preferably glass fibers are used. The fiber length and the fiber thickness can vary depending on the desired usage area and/or on the manufacturing process. It proves to be advantageous to use fiber lengths of over 1 mm. However, the fiber lengths are preferably over 3 mm and especially preferably between 5 and 25 mm. However, it is basically possible to use any fiber length, as long as a random orientation of the fibers is

achieved through the manufacturing process. The fiber thickness is preferably about 10 to 26  $\mu\text{m}$ . In this case, the fibers used do not have a preferred orientation in the core layer, their orientation is random. Non-fibrous materials that are suitable for reinforcing the core layers include inorganic fillers like talcum, chalk, stone dust, saw dust or glass beads. Preferably talcum is used as a non-fibrous reinforcement material. The particle size of the non-fibrous reinforcement material is preferably 3 to 60  $\mu\text{m}$ .

The content of reinforcement material in the core layer preferably lies between 1 and 50 weight-% and especially preferably between 5 and 40 weight-%.

The manufacturing of the core layers of the components according to the invention is carried out, for example by manufacturing methods /3 known from the state of the art, for example by simple admixture of the reinforcement material to the granular matrix material or directly to the melted matrix material and subsequent extrusion.

To reinforce the core layers and/or as a core layer itself, a recycled material of fiber-reinforced polymers can be used. This means, for example, that scrap panels or trimmings that consist of fiber reinforced thermoplastics of one or more of the types listed above are crushed and added to the matrix material for the core and/or the core can be manufactured completely of this recycled material.

If necessary, still other of the usual additives, like dyes, pigments, flame retardants, etc. can be added to the core layer.

The cover layers of the components according to the invention are different from the core layers with fibers reinforced in the form of a coherent surface structure, wherein the fibers are essentially oriented parallel to the surface of the cover layer. Coherent surface structures can be woven fabrics, frayed material, meshes, knits, non-wovens or mats that can be either isotropic or anisotropic. In this process, the fibers used can be fibers of glass, carbon, aramide, ceramic or metals, both natural fibers and synthetic and/or semi-synthetic fibers that are not damaged or not significantly damaged at the processing temperatures of matrix polymers, like cellulose fibers or hemp. Preferably glass fibers are used. In this case, the fiber length depends on the surface structure used and/or its manufacturing method.

It proves to be advantageous to use fiber lengths of over 25 mm. Preferably fibers between 50 and 200 mm are used for non-wovens and mats. The use of continuous fibers is preferably used, e.g. for frayed material, meshes, woven fabrics and knits. The fiber content in the reinforced cover layer preferably lies between 5 and 70 weight-% and especially preferably between 15 and 60 weight-%. The cover layers can also contain the usual additives like dyes, pigments, stabilizers, etc.

The manufacturing of the cover layer can also be carried out using manufacturing methods known from the state of the art, for example by impregnation of the surface structure to be used for reinforcement with the corresponding matrix polymers by means of a

twin press or multiplaten press.

The multilayer components according to the invention consist of at least one core layer that is connected to at least one upper and one lower cover layer. However, the multilayer components can also consist of more than 3 layers, whereby the core layer can be constructed of one or more layers. Also the cover layers can have multiple layers, e.g., to achieve specifically desired, directionally-dependent characteristics or to achieve a desired visual effect.

In addition, one or more surface layers that are free of reinforcement can be applied to each of the individual cover layers. These surface layers can contain other additives, like stabilizers, antistatic agents, conductive additives, flame retardants or dyes.

Preferably the components consist of only one core layer lying in the middle and one cover layer arranged on the top and bottom.

The thickness and shape of the components can vary depending on their usage area. This means, for example, flat panels, but also components with different thickness can be manufactured. The layer thickness of the components according to the invention preferably lies at a total thickness of at least 2 mm and maximum 200 mm and especially preferably up to maximum 100 mm. However, layer thicknesses over 200 mm are also possible if desired.

The manufacturing of the components according to the invention is carried out in that the appropriate number of core and cover layers described above are pressed together to the appropriate shape in a press. Depending on the thermoplastics used, it can be advantageous to

use bonding agents or adhesive films between the individual layers in order to improve the connection of the cover layers with the core layer. Another manufacturing possibility is, e.g., common pressing of matrix material for the core layer that will be applied in the form of granulate, mixed with the appropriate reinforcement material, between two molds that already contain the cover layers that have been manufactured previously. Besides that, it is also possible to manufacture the components in only one work step, i.e., the cover layers are not manufactured in advance.

The multilayer components thus obtained have high flexural strength with high permissible deformation and are therefore especially suitable for manufacturing floors, especially double floors for cable or sports floors, of filter elements for filter presses, tank filters, pressure, drum, disk filters and Buchner funnels. Besides that they are suitable for manufacturing different panels, semi-finished products and molded parts that have high stiffness and high permissible deformation with limited thickness.

Example 1:

On a multiplaten press, a panel is manufactured of a core layer and an upper and lower cover layer by pressing at 200°C and a press pressure of 20 bar. The heating time is 15 min, the cooling time 20 minutes. The panel had the following composition:

Upper cover layer	DAPLEN TC-U20 (PCD Polymere Co.)	1.8 mm
Core layer	DAPLEN BEC 50 T30 (PCD Polymere Co.)	6.4 mm
Lower cover layer	DAPLEN TC-U20 (PCD Polymere Co.)	1.8 mm

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The total height of the panel was thus 10 mm.

DAPLEN TC-U20 is a glass-mat reinforced polypropylene with a weight per surface area of  $1870 \text{ g/m}^2$  and a glass fiber portion of 20 weight-%.

DAPLEN BEC 50 T30, in contrast, is a polypropylene that contains 30 weight-% talcum as a reinforcement.

The panels are subjected to a 3-point bending test according to ISO 178. The bending modulus determined in this way was  $4000 \text{ N/mm}^2$ .

Example 2:

A panel was manufactured analogously to Example 1, which contains a core layer of a recycled material of a 2.1 mm thick DAPLEN TC-U30 (PCD Polymere Co.).

The covers layers remain unchanged. The total height of the panel was 10 mm. The bending modulus determined according to ISO 178 was  $4800 \text{ N/mm}^2$ .

Example 3:

A panel that contains the non-reinforced core layer of natural Daplen BE 50 was manufactured analogously to Example 1 as a comparison sample.

The overall panel had a total height of 10 mm. The bending modulus determined according to ISO 178 was  $3200 \text{ N/mm}^2$ .

**Patent Claims**

1. Reinforced multilayer components of thermoplastics with at least one core layer that is connected with at least one upper and one lower cover layer, characterized in that the core layer contains reinforcement material in unstructured and essentially disconnected

form and the cover layers contain fibers in the form of a coherent surface structure, whereby one or more reinforcement-free surface layers may be applied to the cover layers.

2. Reinforced multilayer component according to Claim 1, characterized in that polyolefins, polyamides, polyether ketones, polyether sulfones, polyethylene or butylene terephthalate, polystyrenes, polyvinyl chloride, polycarbonates or polyoxymethylene are used.

3. Reinforced multilayer component according to Claim 1, characterized in that polyolefins are used as thermoplastics.

4. Reinforced multilayer component according to Claim 1, characterized in that it has a core layer and an upper and lower cover layer.

5. Reinforced multilayer component according to Claim 1, characterized in that individual fibers or non-fibrous inorganic fillers are used as a reinforcement material for the core layer.

6. Reinforced multilayer component according to Claim 5, characterized in that as reinforcement material, fibers are used of glass, carbon, aramide, ceramic or metals or natural fibers, as well as synthetic or semi-synthetic fibers that are not damaged or only insignificantly damaged during the processing of the thermoplastics.

7. Reinforced multilayer component according to Claim 5, characterized in that talcum, chalk, stone dust or glass beads are used as non-fibrous inorganic fillers.

8. Reinforced multilayer component according to Claim 1,

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characterized in that fibers in the form of a woven fabric, frayed material, mesh, knits, non-wovens or in the form of mats are used as reinforcement material for the cover layers.

9. Reinforced multilayer component according to Claim 1, characterized in that the percentage of reinforcement material in the core layers is 1 to 50 weight-%.

10. Reinforced multilayer component according to Claim 1, characterized in that the percentage of reinforcement material in the cover layers is 5 to 70 weight-%.

11. Reinforced multilayer component according to Claim 1, characterized in that the surface layers free of reinforcement contains additives like stabilizers, antistatic agents, conductive additives, flame retardants or dyes.